NATIONAL AERONAUTICAL R&D GOALS

TECHNOLOGY FOR AMERICA'S FUTURE

Executive Office of the President
Office of Science and Technology Policy

FOREWORD

In November of 1982 an interagency working group, under the direction of the White House Office of Science and Technology Policy, issued a comprehensive report analyzing the state of aeronautics research and the role of the Federal Government in supporting that research. Among its conclusions were that there are possible today monumental advances in aircraft performance. Due to the nature of the benefits, both military and commercial, the Federal Government and industry must unite to realize that potential.

As a result of that report, I established an Aeronautical Policy Review Committee, composed of government, industry, and academic experts, for the purpose of keeping track of the implementation of the recommendations in the first report. This second report by the Committee points out that, like other industries that rest on strong technological bases, American aeronautics faces tremendous challenges from abroad as well as tremendous opportunities for advances and leadership now and in the future.

The report is comprehensive and addresses specific goals in three areas—subsonics, supersonics, and transatmospherics—that we should be focusing on. It gives clear direction for the Administration's commitment to maintaining and extending our leadership in this field. If the goals are pursued vigorously by industry, academia, and government, U.S. aeronautics, in both the civil and defense sectors, will be able to sustain its preeminence into the next century.

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EXECUTIVE SUMMARY

Challenges and Opportunities

U.S. aeronautics is and will remain a decisively forceful influence on the long-term economic and military security of the nation. The technical margins that have long defined U.S. aeronautical preeminence have narrowed significantly in recent years as foreign competition has increased. This trend, if allowed to continue, will evolve into major national weaknesses substantially increasing the vulnerability of America's position in world affairs. Because aeronautics is so integral to our national interest, U.S. national aeronautical policy now stipulates that the nation cannot and will not allow leadership erosion.

Lasting U.S. aeronautical leadership will only be secured by the vigorous renewal of America's traditional strength: pioneering new technology. Aeronautical opportunites are known today which, if actively pursued, would result in 21st century U.S. civil and military aircraft of clear-cut superiority. Their technical excellence and cost advantages could more than overcome foreign competitive approaches.

Strategy and Goals for U.S. Aeronautics

The high-technology payoffs that result from advances in aeronautics are important national benefits that must be maximized by American enterprise. This maximization requires both government and industry to combine their efforts toward aggressive technological goals with potential for broad future application. In this pursuit, early

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applications can help generate the national resources and experience needed to capitalize on the opportunities that will follow. This strategy also supports the more definitive objectives for technically superior U.S. military aircraft.

The Committee proposes three national goals to clarify and focus the direction for U.S. aeronautical R&D. Successful attainment of these goals will challenge American creativity. Within the next 10 years the U.S. must build its research and technology momentum and achieve a trans-century renewal of the nation's total aeronautics capacity. Work must proceed concurrently on all three goals, with early emphasis on the first. The goals are presented here in time-phased order of attainment:

Subsonics Goal: To Build Trans-Century Renewal

- Envisions technology for an entirely new generation of fuel-efficient, affordable U.S. aircraft operating in a modernized National Airspace System.
- Captures immense civil aircraft market opportunities by technologically superseding foreign competitive challenges.
- Supports development of advanced military aircraft capabilities.
- Requires acceleration of key technology advances for 1995 readiness target. Applications well into the next century.

Supersonics Goal: To Attain Long-Distance Efficiency

- Develops pacing technologies for sustained supersonic cruise capability.
- Enables linking of farthest reaches of Pacific Rim in four to five hours. Recognizes growing U.S. strategic and economic interests with partnership potential.
- Provides military with enhancements in basing flexibility, long-distance responsiveness, and survivability.
- Applications through much of the next century.

Transatmospherics Goal: To Secure Future Options

- Pursues research toward capability to routinely cruise and maneuver into and out of the atmosphere with takeoff and landing from conventional runways.
- Builds on progressive subsonic, supersonic, and hypersonic advancements in aeronautics technology as well as Space Shuttle experience.
- Influences long-range options for both aeronautics and space.
- Significant to military and civil 21st century leadership.

Collectively, these goals will focus national energies and creativity on new frontiers and opportunities that are vital for the future success and leadership of America.

Implementation Challenges

America's future in aeronautics demands much more than a "business as usual" attitude. U.S. industrial companies must work with one another, and with government agencies, to increase *accomplishment* and enhance *affordability*.

Historically, a number of barriers have impeded technological advancement in both the public and private sectors. The current environment amplifies the impact of many of these impediments on achieving technology readiness. Appropriate corrective actions exist, and should be pursued without delay:

- Federal contracting procedures should be restructured to reflect a greater distinction between the procurement of research and technology and the procurement of hardware.
- Regulatory policy should encourage cooperative efforts for technology development among U.S. companies (as is now ongoing between U.S. and offshore companies).
- Federal tax legislation should adequately stimulate private investment in timely technology development.
- All branches of the Government with relevant oversight and/or management responsibilities should strive to maintain the continuity of research and technology development activities.

Planning, Priorities, and Policies For Action

Technical plans for implementing these goals must be developed in close conjunction with the reordering of national R&D priorities and policies. This task challenges both public and private sector creativity to gain real growth in aeronautical technology development. It also challenges government leadership to reconcile policies inhibiting R&D progress and affordability. Toward this national purpose, the Executive Offices and mission-oriented agencies of government must work closely with Congress to ensure that the rich potential in aeronautics is nurtured, encouraged, and firmly secured as an American reality.

INTRODUCTION

U.S. Aeronautics in a Global Context

U.S. aircraft have long dominated in civil aircraft markets and in weapon system technical superiority, but there is no guarantee that U.S. leadership in aeronautics will be retained even in the short term. In fact, the U.S. can no longer assume its leadership is secure on any high technology front. Very clearly, the intensity of global competition in high technology poses a serious challenge to U.S. aeronautical preeminence, a situation which also brings into question the economic and strategic future of the United States. Aeronautics has a crucial role both in America's defense capabilities and in the employment, transportation, and exports which strengthen our national economy.

In aeronautics, the U.S. system of private enterprise has developed a unique base of national synergy which affects key parts of the nation's overall competitiveness. Aircraft provide a challenging product focus that stimulates high technology innovation from a broad array of contributing companies and industrial sectors. The success of this aspect of America's aeronautical infrastructure has not gone unnoticed by other nations, and aircraft capacities have become favored targets for foreign technological and industrial expansion over much of the past decade.

While U.S. aircraft still maintain a broad base of technological advantage, the margin of that advantage has narrowed dramatically in recent years. In a growing number of aircraft-related areas, foreign technical capabilities are now comparable, if not superior, to those of the U.S. This is particularly evident for smaller aircraft, where the entry threshold has been within the financial and technical reach of an increasing number of smaller nations or multinational consortia. Foreign military aircraft capacities are now showing a similar trend. Coupled with this, military and civilian aircraft technologies and products have become a politically sensitive aspect of international negotiations and trade. In this respect, the erosion of American preeminence implies major negative consequences for the position of U.S. leadership in global security as well as for the vitality of U.S. industry in a changing global economy.

An Expanding Perspective

All these factors were recognized in the Administration's 1982 Aeronautical R&T Policy, which established challenging national goals for furthering all aspects of U.S. aeronautical preeminence. Following one of these policy recommendations, the President's Science Advisor formed a senior executive-level committee to review (from a national perspective) the Government's long-range aeronautical plans for consistency with the policy objectives. This is the second report submitted by that policy review committee.

The Committee's first report, submitted to the Executive Office of the President in November 1983, included a number of recommendations to encourage a more aggressive and farsighted national outlook for aeronautics. During 1984, the U.S. aeronautical community reexamined opportunities for technological advancement that could be achieved by the end of this century. This crucial evaluation was conducted with a view toward vehicle concepts that reached beyond the arbitrary time horizon of the turn of the century. The results presented to the Committee both confirmed and expanded many earlier assessments. Very high-leverage payoffs can be expected from interdisciplinary efforts in propulsion, materials, aerodynamics, structures, and avionics. Aggressive technological readiness can produce either a distinct U.S. advantage or, conversely, an advantage to foreign civil and military competitors, depending on where the greatest effort and commitment are made. In considering this dynamic situation, several important factors should be borne in mind:

- Leapfrog advancements are definitely possible which would make obsolete virtually all significant civil and military aircraft operational today (both fixed and rotary wing).
- The range of high-payoff R&T opportunities impacts all classes of aircraft and will far exceed resources available for investment.

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Three long-range goals are proposed to address all these challenges and opportunities. The Committee believes that the highest potential for revitalizing U.S. competitiveness lies in America's traditional area of strength: the pioneering of new technology. The three goals proposed here are aligned to form a strategy aimed at a decisive strengthening of the U.S. technological foundation and leadership position in world markets and relative to our military adversaries.

The goals are time-phased, with the first goal (subsonics) being crucial as an enabling goal. It must serve to reenergize American R&D momentum, because the product technologies it fosters must generate private sector resources necessary for exploitation of ensuing opportunities in supersonic and transatmospheric flight. While payoffs will be time-phased in their realization, it is important that work toward all three goals proceed concurrently. Emphasis over near-term years, however, must necessarily be focused on the first goal.

Subsonics Goal: To Build Trans-Century Renewal

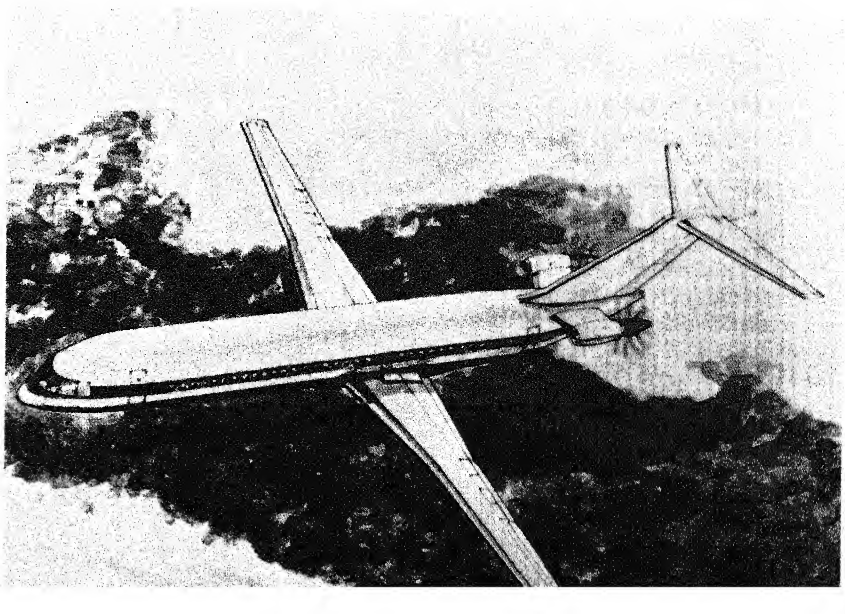
Advancing technology for a new generation of U.S. subsonic aircraft

The past 15 years have seen mostly evolutionary advancements in subsonic aircraft technology, but future possibilities for truly revolutionary advancements far exceed all these. Subsonic opportunities can establish a firm U.S. foundation for technically superior aircraft to carry U.S. aeronautical leadership into the next century. The subsonics goal envisions this with an entirely new generation of fuel-efficient U.S. aircraft operating in a flexible and modernized National Airspace System. Simply stated, its aim is a safe, congestion-free U.S. aeronautical interstate system, offering superior air transportation at half its current cost. The subsonics goal also envisions the development of advanced military airlift capabilities, long endurance aircraft, low observables, rotorcraft, and other spin-off military requirements that are anticipated for the same general time frame.

Accelerating subsonic technology can leverage unique advantages for the United States, by capitalizing on the pioneering efforts in airspace modernization and deregulation already in the national agenda. It also promotes domestic supply for the very large U.S. civil aircraft markets. In this respect, subsonic aircraft also dominate in world market projections, with a variety of requirements extending well into the next century. This immense civil opportunity is the cornerstone for sustaining American aircraft capacities, since civil work generates 60 percent of the total aircraft production business for the 15,000-company supplier base which supports both U.S civil and military needs. Foreign competition has already placed serious technology readiness pressures on the U.S. supply base, particularly with respect to smaller classes of aircraft (commuters, business aircraft, and rotorcraft) where the position of U.S. products is most endangered today.

Significant national research and technology development is already in progress. However, key subsonic advances contributing to new trans-century aircraft must be accelerated and readied by the mid-1990's to meet crucial competitive applications that will affect U.S. aeronautical momentum into the next century. Technologies that are integral to the development of these subsonic aircraft include: laminar flow control advancements that substantially reduce aircraft drag; all composite high-strain structures; a new generation of super bypass and propfan engines; and fully integrated flight controls and operating systems that interface with National Airspace System modernization. It is essential for the National Airspace System Plan to maintain cohesiveness and flexibility to accommodate and keep pace with these future aircraft technologies. Advanced computational capability is key for both aircraft and air system objectives.

New aircraft in the system will more than double today's best fuel efficiency, as well as being substantially more efficient in operation. U.S. general aviation, rotorcraft, commuters, and transport aircraft that decisively reduce acquisition and operating costs will dominate established world



markets and the new air service expansions of developing nations. U.S. helicopters and V/STOL aircraft will also become increasingly important in both these market areas. Advanced aircraft of this type can reduce congestion in U.S. airports and provide transportation infrastructure unique to the specialized requirements of developing nations.

Achievements of this magnitude could also produce a U.S. advantage in the eventual formation of a globally compatible air system, as well as leadership in other areas of international aviation. This in turn could leverage significant U.S. strategic and economic advantage for other important world agendas, particularly in the developing Pacific region.

Stepping up national research momentum and efficiency is a vital part of this far-reaching goal. In view of this, a broad, trans-century strategy is proposed later in this report that places particular emphasis on revitalizing the nation's capacities for aeronautical innovation over the next decade.

Supersonics Goal: To Attain Long-Distance Efficiency

Developing technology for efficient, long-distance supersonic cruise

Gaining sustained supersonic cruise capability is of very high priority for future military aircraft survivability, long-distance responsiveness, and basing flexibility. However, this military capability is also aligned with highly constructive civil opportunities that could benefit the U.S. in important non-military areas as well. Supersonic advancement offers the added potential for welding long-term bonds between the U.S. and Pacific partners through possible joint development of the pacing technologies for a new generation of supersonic transports. The key technologies underlying this objective (propulsion, structures, materials, and aerodynamics) are largely generic to future military needs.

Strategically and economically, United States trade and alliances in the Pacific have major implications for the future. The region's dynamic growth and vast potential for development should continue to be influenced and encouraged by American policy and enterprise. U.S. trade with the Pacific community has increased over 75 percent within the last six years, accelerating well beyond the volume of trade with Europe. Mutual security bonds are also of increasing significance in light of a potential major Soviet military buildup in the region. From both the strategic and economic perspectives, the vast Pacific area is constrained by distance, a factor adding significance to a U.S. supersonic goal . . . and contributing to the potential for Pacific Rim development by increasing cooperation and understanding among the nations and peoples of this important region.

The key technologies for advancing supersonic cruise capability have not been aggressively pursued by the U.S. since the 1971 demise of the U.S. Supersonic Transport program. However, the NASA-funded Supersonic Cruise Research program, which ended in 1981, established a constructive base for further advancement. The development of single crystal turbine blades, better coatings, advanced cooling methods, and improved internal aerodynamics has allowed significant improvements in military engine thrust-to-weight ratios. The application of these technologies to a variable cycle engine with reduced noise, and much improved specific fuel consumption over the entire speed regime, forms a starting basis for the Pacific Supersonic Transport.

The application of powder metallurgy technology and superplastic forming techniques to load-carrying structure, along with new thermoplastics, carbon-carbon, and metal matrix materials, will also have significant benefit for all classes of military and civilian supersonic aircraft. Additionally, fault-tolerant computers that provide load alleviation and dynamic damping, coupled with the cooler structure allowed by supersonic laminar flow, will significantly reduce the aircraft weight per pound of payload as compared with earlier supersonic transports.

The advent of powerful computer systems will allow the computation of complex flows and the

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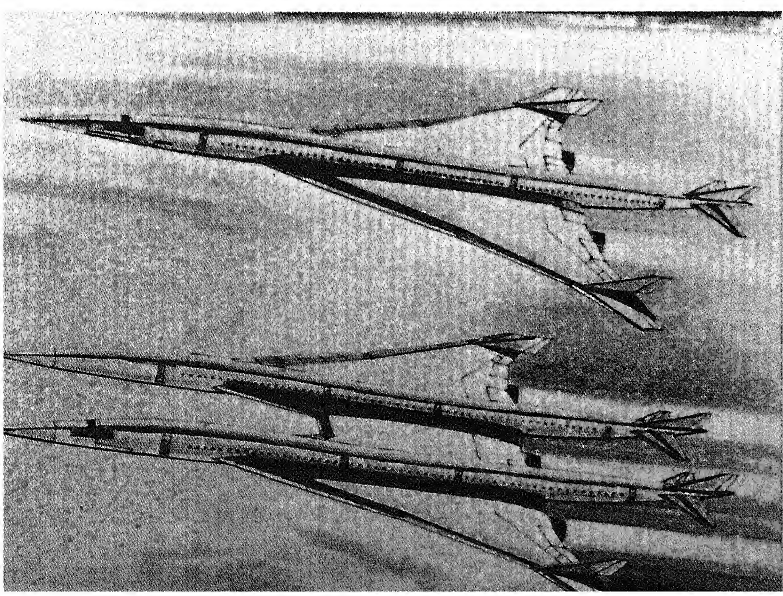
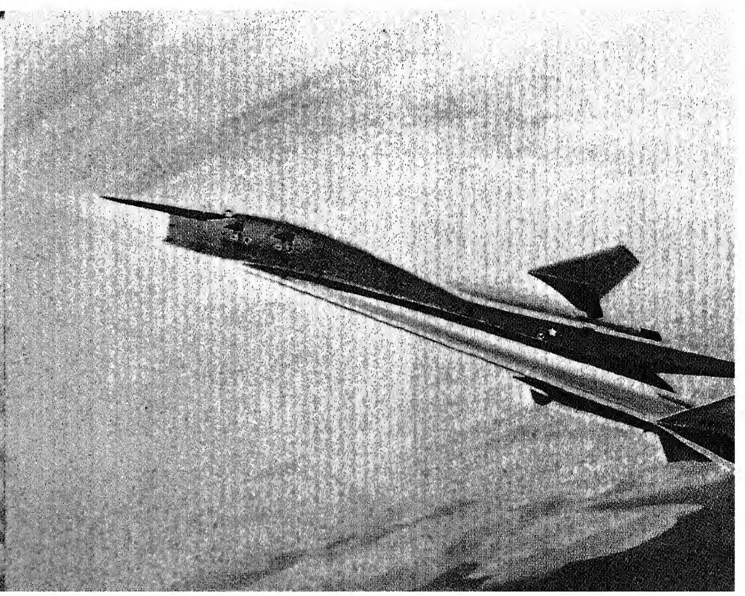




"From both the strategic and economic perspectives, the vast Pacific area is constrained by distance, a factor adding significance to a U.S. supersonic goal."

optimization of configurations that extend the regions of supersonic laminar flow. A complete understanding and verification of the potential for supersonic laminar flow is critical for sustained cruise speeds that would allow both military and civil aircraft operations at triple the fuel efficiency of today's supersonic technologies. Combined with other supersonic advances, it can also substantially reduce the overpressures contributing to sonic booms.

Creative integration of these technologies could provide the U.S. and its Pacific allies with a transportation system linking the farthest reaches of the area in four to five hours, while providing the military with vitally needed mission enhancements in basing, long-distance responsiveness, and survivability.

Transatmospherics Goal: To Secure Future Options

Exploiting the growing convergence of aeronautics and space technology

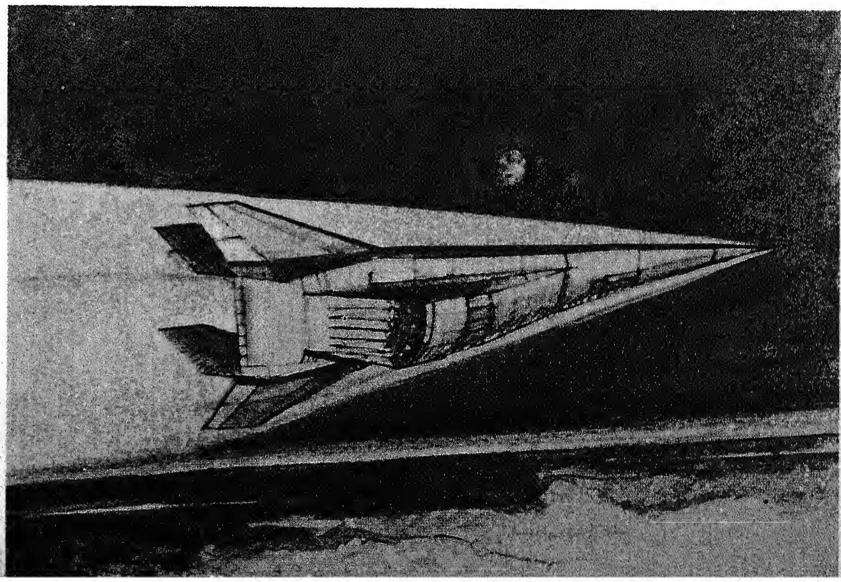
U.S. aeronautics and space endeavors share in related constraints and unexploited opportunities in the transatmospheric regime. The capability to routinely cruise and maneuver into and out of the atmosphere, to gain rapid responsiveness for low earth orbit missions (manned or unmanned), or to attain very rapid transport services between earth destinations from conventional runways must be viewed as aerospace options with global importance for the future.

The importance of these capabilities to the U.S. must be underscored, since all these possibilities are also open to foreign military or civil initiatives in either aeronautics or space. The U.S. has largely viewed the transatmosphere as a technical boundary . . . used to define the separate responsibilities between U.S. aeronautics and space. This is a view foreign competitors may not hold, since aeronautics and space technologies are rapidly converging.

This convergence makes it vital for the U.S. to establish a long-range goal for understanding and better exploiting this important bridging regime. Increased understanding of the transatmospheric environment and its relationship to maneuvering vehicle requirements must be gained within the near term. This knowledge will be highly significant to the selection of high-payoff developments in propulsion, fuels, materials, system concepts, and other areas which may influence future national options in space and/or aeronautics.

Much of the flight vehicle technology base is expected to develop from the progressive subsonic, supersonic, and hypersonic advancements in aeronautics as well as from Space Shuttle experience. Follow-on advancements in lightweight structural and thermal protection concepts involving new materials systems, artificial intelligence advancements, and blended body aerodynamics are also part of the progressive technology development scenario. Hybrid air-breathing propulsion systems, the truly pacing technology for conventional and routine operations from earth, are now viewed as feasible over the long term. Major fuel system/propulsion advancements may also be possible that would extend vehicle capabilities to high earth orbit missions.

The U.S. must seriously consider that the proliferation of world space activities will eventually call for more conventional forms of transport having the earth-based flexibility possible with transatmospheric flight. There are also very important future military options possible. The extreme altitude and speed capabilities this technology makes possible could enhance military survivability in lethal environments and provide flexible basing for global range weapons delivery, reconnaissance, or space support missions.



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oals outlined here are to be met, urn and efficiency must be ener- al scale. Toward that end, a strat- hat places primary emphasis on vitalize the nation's capacities for vation over the next decade.

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ed national program of basic R&T d and sustained to produce the l ideas essential to technological continuous flow of fundamental both public and private research is ices and breakthroughs are to

. nation's basic research, as well as ientific and engineering man- ned within the American univer- gnificant expansion of industry and nsorship of basic research at the s needed to encourage and sustain iversity contribution to America's kill base. In particular, increased arch relationships between indus- rsity system will provide valuable all aeronautical momentum.

l Industry

level, highly important aeronauti- conducted directly by government stry. Basic research and technology is the bedrock for future technol- overnment and industry research l phenomena understandings and nology evolutions that lead to eronautical advances. A continuity nese fronts — government, indus- ty — must be stressed to maximize s highly important aspect of trans- ation.

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trans-century momentum in ment must be established within s. This becomes patently clear in that only some 25 years elapsed -3 technology era and the advent st generation of commercial jet ll indications, future leaps in aero- gy will be achieved within much nes. We can also anticipate, from l experience, that the acceleration lvancement will lead American ' frontiers of opportunity. America epared to take advantage of these

Address the Issue of Affordability

Sustained preeminence will require both *cost* and *technical* superiority from U.S. aeronautics. Affordability, or the cost of acquisition, is a major problem confronting both military and civil aircraft programs today. The Committee believes that cost will remain a major impediment to national progress and competitiveness until more concrete steps toward solution are taken.

Partial solutions can be realized in the technologies directly affecting the product level. Advanced manufacturing and product management concepts are all-important in this respect, but partial solutions are not the answer.

Energizing the R&T Chain

Product costs are highly influenced by the degree of continuity and effort employed at the early stages of research and technology. The most critical area is technology validation, the mid-phase in the R&T chain. This phase takes potentials identified from basic research (the first phase) and advances them into risk-acceptable readiness; the final phase then entails product application and production. National policies and implementing procedures that influence or direct technology have driven unintended barriers into this critical mid-phase of R&T, causing this vital link in the innovation chain for aeronautics to be short-circuited.

There is no question that achieving technology validation and readiness of high-payoff potentials is the most costly and time-consuming aspect of research and development. It requires more time and more money than many persons in program advocacy positions are prepared to recognize or admit to. In truth, significant accomplishment is required before specific system needs are known or program commitments made. It is seldom fully recognized that production failures, program delays, or cost overruns may have been preordained because the risks in critical technologies were not sufficiently understood, and not reduced by appropriate feasibility demonstration experiments, before program commitments were made.

Civil and Military Synergy

There are highly constructive synergies that can be brought into play to affect affordability. For example, military advancements stress performance; on the other hand, commercial developments tend to emphasize lowered production costs, vehicle operating efficiency, and high availability with low

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